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Global infection prevention gaps, needs, and utilization of educational resources: A cross-sectional assessment by the International Society for Infectious Diseases☆

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ABSTRACT

Objective: The *Guide to Infection Control in the Hospital (Guide)* is an open access resource produced by the International Society for Infectious Diseases (ISID) to assist in the prevention of infection acquisition and transmission worldwide. A survey was distributed to 8055 current *Guide* users to understand their needs.
Methods: The survey consisted of 48-questions regarding infection prevention and control (IPC) availability and needs. Dichotomous questions, Likert scale-type questions, and open-and closed-ended questions were used.
Results: Respondents (n = 1121) from 194 countries and six WHO regions participated in the survey. 43% (488) identified as physicians. Personal protective equipment (PPE) availability, training, and antimicrobial susceptibility testing varied between regions. Only 11% of respondents from low-income countries reported consistent access to respiratory equipment, 12% to isolation gowns, 4% to negative pressure rooms or personnel trained in IPC, and 20% to antimicrobial resistance testing. This differed significantly to high and upper middle-income resource settings ($p < 0.05$). 80% of all respondents used smartphones or tablets at the workplace.
Conclusions: This survey demonstrates varied access to IPC equipment and training between high and low-income settings worldwide. Our results demonstrated many respondents across all regions utilize mobile technology, providing opportunities for rapid distribution of resource specific, up-to-date IPC content.

Introduction

Hospital-acquired infections are a significant contributor to health care-associated patient morbidity and mortality, particularly in low- and middle-income settings (Vilar-Compte et al., 2017). Infection prevention and control (IPC) measures as well as antimicrobial testing are critical to combatting these. Various national and international guidelines are available to that end, however many of these published materials are not updated on a regular basis, require payment, are difficult to access in the hospital setting, or are oriented towards high income settings (Larson et al., 2007; Zimmerman, 2007).

The International Society for Infectious Disease (ISID) is a not-for-profit organization founded in 1986 to improve the care of patients with infectious diseases, the professional development and standing of clinicians and scientists in the field, and the control of infectious diseases around the world with an emphasis on low-and middle-income countries. Since 1998, the ISID has developed and distributed "*A Guide to Infection Control in the Hospital*," which is a publicly available resource dedicated to outlining principles around IPC processes (Wenzel et al., 2017). With more than 60 chapters, the authors intend to improve the quality of care, minimize risk, save lives, and reduce costs. More than 50,000 print copies have been

☆ Preliminary findings from this study were presented at the 18th International Congress on Infectious Diseases, Buenos Aires, Argentina March 2018.

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distributed freely worldwide since that time. In 2015, ISID made the *Guide* available as an open access pdf document with more than 10,000 unique downloads from over 160 countries to date.

To better understand the needs of practitioners around the world, and in anticipation of an updated 6th edition of the *Guide*, an electronic needs assessment survey was designed and distributed to individuals that had downloaded the 5thedition of the *Guide*. Previous studies have demonstrated that IPC programs are often underdeveloped in low-and middle-income countries (LMICs) due to financial limitations as well as lack of structured support (Damani, 2007; Sastry et al., 2017). An assessment of IPC equipment and education available in LMICs was of particular interest in this survey and is highlighted in the results below.

Methods

An electronic survey was developed in January 2017 and distributed to 8055 unique users who downloaded the previous 5th edition PDF version of the *Guide*. The survey was distributed by email and completely de-identified. The original survey was hosted using the TypeForm® platform.

The survey contained 48 questions that were developed in the following categories: Availability of specific IPC resources i.e. antimicrobial susceptibility testing, personal protective equipment, isolation rooms; training in IPC; access to technology at the workplace; usage of the *Guide* and other resources in clinical work; and users' needs for the next edition. These categories were chosen to better evaluate general accessibility to IPC processes, particularly among respondents from LMICs.

Dichotomous questions, Likert scale-type questions, and open- and closed-ended questions were utilized in the survey. Questions regarding general demographics allowed users to respond with more than one identifying feature, while questions that addressed access to IPC material and education typically allowed for only one type of response. Conditional branching was applied to select questions. The survey completion period was defined between January and February 2017. Responses were further categorized based on WHO region; the exception to this was within the Americas.

In order to gain a more granular view, responses were also grouped by economic classification. Economies were divided into four income groups: low, lower-middle, upper-middle, and high. Income was measured using gross national income (GNI) per capita per World Bank designations (World Bank Group, 2018). Low-income economies were defined as those with a GNI per capita, of $1005 or less in 2016; lower middle-income economies were those with a GNI per capita between $1006 and $3955; upper middle-income economies were those with a GNI per capita between $3956 and $12,235; high-income economies were those with a GNI per capita of $12,236 or more.

Analysis

Microsoft Excel 2011® was used for collection of data as well as basic visualization. Primary analysis of the data was purely descriptive, however sub-analysis evaluating differences of access to supplies and support services among World Health Organization regions utilized a Chi-squared measure of association. A *p-value* of less than 0.05 was considered significant in the course of this analysis.

Results

Participant characteristics

Of 8055 members contacted, 1121 completed and submitted responses to the 48 questions on the survey, a response rate of 13.9%. In total, survey participants came from 194 countries representing all six WHO regions. For the purposes of this study, the WHO region designated as the Americas was separated into North America and Latin America as examining the data at a granular level provided additional insights into relevant disparities. Survey respondents originated from South-East Asia (218; 19%), Europe (206; 18%), North America (205; 18%), Africa (183; 16%), Latin America (126; 11%), Eastern Mediterranean (103; 9%), and Western Pacific (80; 7%). The majority of survey participants were from low- and middle-income countries (671; 60%). 40% (450) of survey participants were from high-income countries as defined by the World Bank country income classification. Figure 1a and b details survey participants by country income level and WHO region.[1]

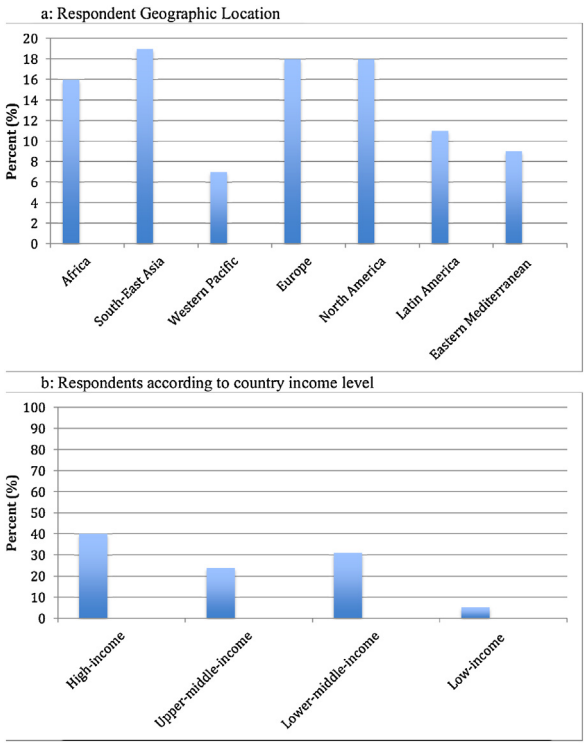


Figure 1. (a) Respondent Geographic Location. (b) Respondents according to country income level.

The majority (606; 54%) of respondents were hospital-based, followed by laboratory and public health department-based. In terms of professional designation, respondents were able to designate multiple areas of expertise ranging from clinical to research to public health and policy capacities. A large proportion of survey participants identified themselves in at least one possible category as a clinician. Overall, 42% of respondents (473) self-identified as physician and 6% as nurse (72) in at least one category of demographic designation. Twenty percent (230) of respondents identified in at least one category as a public health professional. Of those, 33% (76) reported to also be a physician or nurse. A significant number of respondents indicated researcher as primary or secondary designation (45%, 510) with 12% (62) of these also indicating physician and/or nurse as an additional demographic designation.

[1] WHO region Americas was subdivided into North America and Latin America for the purposes of granular data reporting.

Access to IPC equipment and training

Access to IPC supplies and training according to WHO region were analyzed and are summarized in Figure 2a–c.[2]

76% (273/357) of survey respondents from high-income countries reported to have consistent access to appropriate respirator equipment to care for patients with tuberculosis as compared to 11% (6/53) from low-income countries, 20% (58/293) from lower-middle-income countries, and 45% (107/237) from upper-middle-income countries. Similarly, 76% (284/371) of respondents from high-income countries reported to have consistent access to isolation gowns versus 12% (7/54) from low-income countries, 21% (64/302) from lower-middle-income countries and 45% (110/243) from upper-middle-income countries. Only 4% (2/47) of respondents from low-income and 5% (15/275) from lower-middle-income countries (15/345) reported that they had consistent access to negative pressure rooms.

Overall, less than half of all respondents noted access to personnel trained in infection control and prevention practices. 63% (256/401) of respondents from high-income countries reported consistent access to personnel trained in IPC, compared to 4% (2/55) of respondents from low-income, 26% (85/325) from lower middle-income, and 33% (86/257) of respondents from upper middle-income countries.

A chi-square test of independence was performed to examine the differences of access to supplies and support services. Access to isolation gowns $X^2(24, N = 966) = 212$, $p < 0.001$, appropriate respirator equipment such as N95 respirators $X^2(24, N = 936) = 191$, $p < 0.001$, negative pressure rooms $X^2(24, N = 900) = 195$, $p < 0.001$, and access to personnel trained in IPC differed significantly $X^2(24, N = 1035) = 147$, $p < 0.001$, differed significantly between WHO regions as well as between country income groupings.

Access to antimicrobial testing

The survey demonstrated clear gaps for IPC training and education, antimicrobial testing and access to antibiotics between WHO regions and between country income groupings. Results are summarized in Figure 3a–c. "I don't know" and "not applicable" responses were excluded from this sub-analysis.[3]

Approximately half of all respondents noted consistent access to antimicrobial resistance testing to assist in appropriate targeted therapy. Across country income groupings, 72% (266/371) of respondents from high-income countries reported having access to antimicrobial resistant testing in comparison to 20% (11/54) from low-income countries, 37% (115/312) from lower-middle income countries and 47% (118/252) from upper middle-income countries. Access to antimicrobial resistance testing $X^2(24, N = 986) = 122$, $p < 0.001$ differed significantly between WHO regions and between country income groups ($p < 0.001$).

Access to technology

Mobile technologies represent an important potential avenue to disseminate up-to-date IPC information rapidly. Overall, 80% (897/1,121) of all respondents noted that they had access to a smartphone at the workplace. 94% of those (842/897) reported accessing the internet at their workplace through their smartphone. There were no significant disparities across WHO regions as 84% (153/183) of African, 82% (84/103) of Eastern-Mediterranean, 72% (148/206) of European, 90% (113/126) of Latin American, 72% (147/205) of North American, 86% (187/218) of South-East Asian, and 78% (62/80) of Western Pacific respondents reported using a mobile device at their workplace. The most commonly used operating system overall was Google Android (60%, 517) followed by Apple iOS (40%, 339). The results are demonstrated in Table 1.

In order to better understand the IPC utilization landscape, we asked respondents how medical information is accessed and more specifically, whether medical guide mobile applications and technology were utilized on available smartphones and/or tablet devices. Of note, slightly more than half (56% or 498/889) of all respondents reported not using medical guide applications on their devices. Among these, 74% (112/152) of African and 61% (113/186) of South-East Asian respondents reported "no," compared to 57% (83/148) and 36% (41/113) of North American and Latin American respondents respectively.

IPC content delivery

IPC content delivery needs differed according to country income grouping. 71% (278/404) of respondents from low-income and lower-middle income countries requested specific recommendations to facilitate IPC implementation across different resource settings as compared to 35% (156/450) of respondents from high-income countries. 74% (309/404) of respondents from low-income and lower-middle income countries wished for step-by-step instructions as compared to 49% (221/450) from high-income countries. 82% (336/404) of respondents from low-income and lower-middle income countries wished for pictograms as compared to 54% (242/450) from high-income countries.

Apart from the *Guide*, we asked respondents to consider what other IPC tools they used to direct best practices in a health care setting. Other IPC guidelines commonly used included those from the World Health Organization (WHO) (78.9%), US CDC (69.1%), Association for Professionals in Infection Control and Epidemiology (APIC) (25%) and the Society for Healthcare Epidemiology of America (SHEA) (23.9%) (World Health Organization, 2018; Infection Control, 2016; Professional Practice, 2019; Practice Resources, 2017).

Discussion

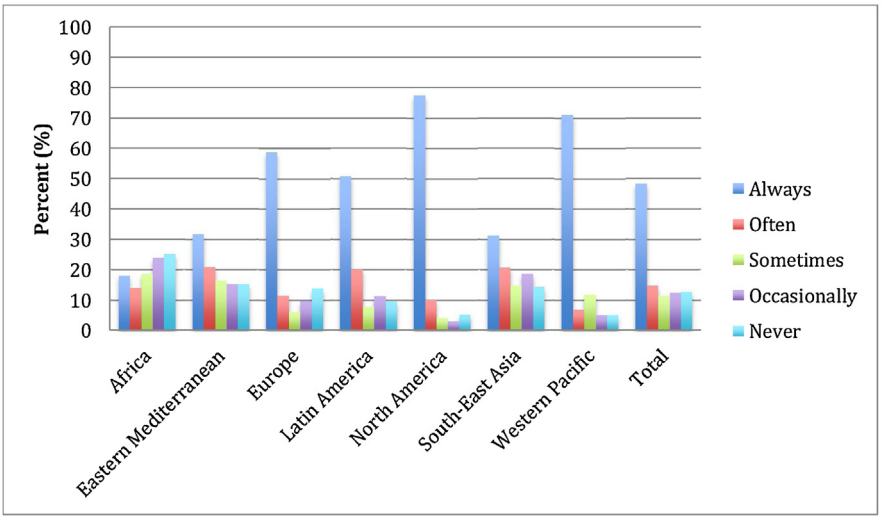
The ISID developed and distributed an electronic survey in January 2017 to address disparities in IPC access and utilization among users of the *Guide to Infection Control*. Survey respondents self-identified primarily as health care providers followed by public health professionals and policymakers from North and South America, Europe, Western Pacific, South-East Asia, and Africa. While country of origin was provided in the survey, we chose to display the results by region and economic classification in order to provide a more macroscopic view. IPC availability and access to relevant resources were assessed through responses to questions regarding utilization of mobile technology, level of support services and supplies, and IPC practices at local health care settings.

This survey demonstrated differences in IPC training and equipment access between WHO regions as well as among LMICs. While a majority of North American, Western Pacific and European respondents noted access to N95 respirators (74% and 71% respectively), African and South East Asian respondents had notably less access to similar supplies (18% and 31% respectively). This trend continued when stratified between income, as 76% of survey respondents from high-income countries reported to have consistent access to appropriate respirator equipment to care for patients with tuberculosis as compared to 11%. While literature

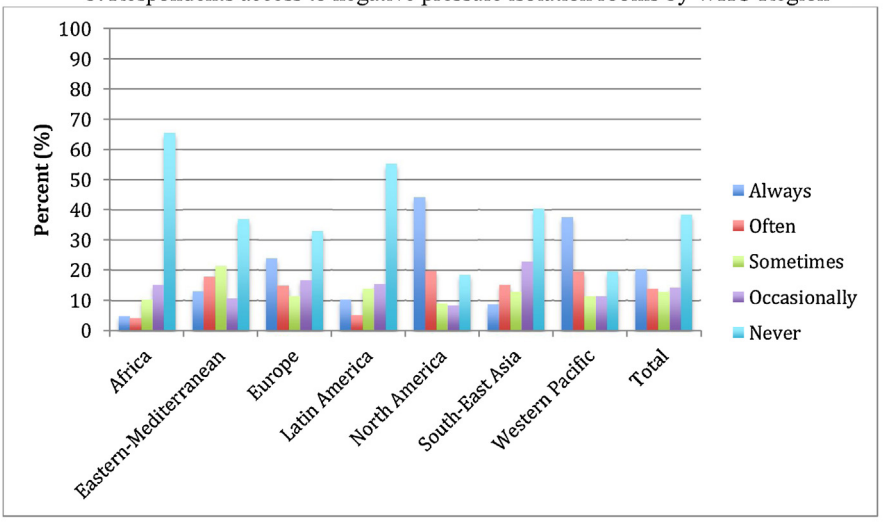
[2] WHO region Americas was subdivided into North America and Latin America for the purposes of granular data reporting.

[3] WHO region Americas was subdivided into North America and Latin America for the purposes of granular data reporting.

a: Respondents access to equipment such as N95 respirators for airborne precautions by WHO Region



b: Respondents access to negative pressure isolation rooms by WHO Region



c: Respondents access to isolation gowns by WHO Region

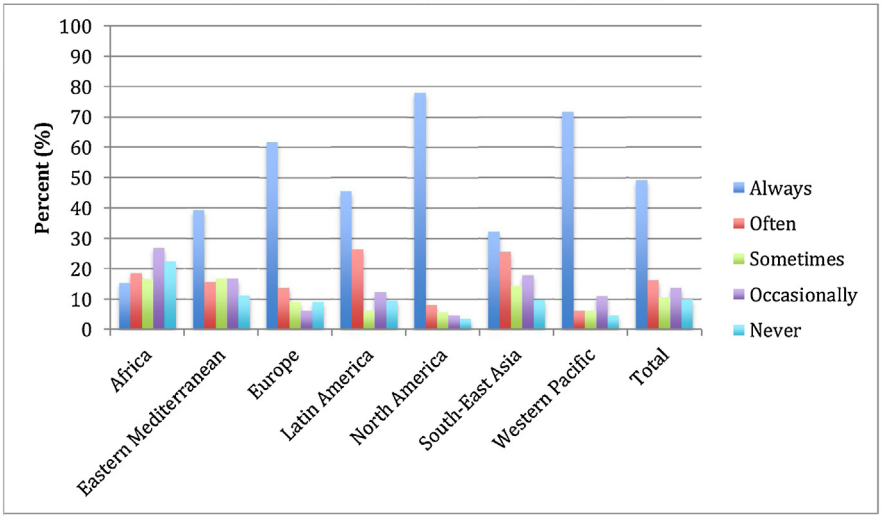
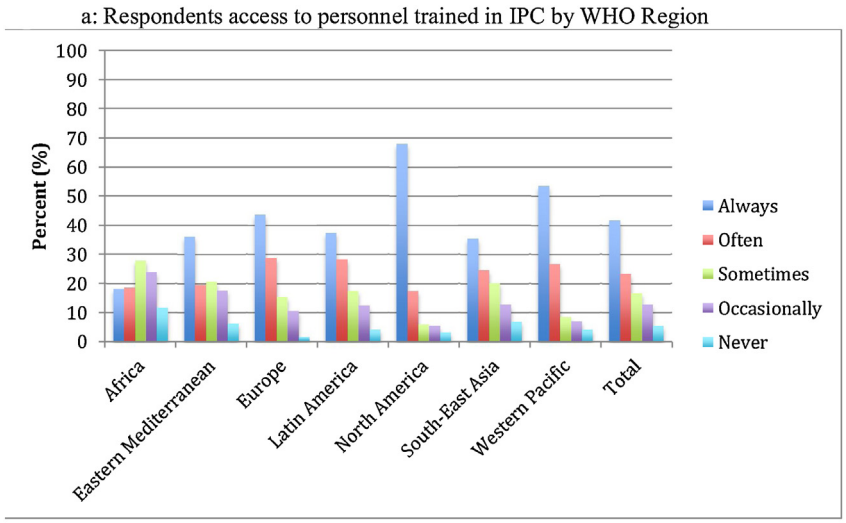
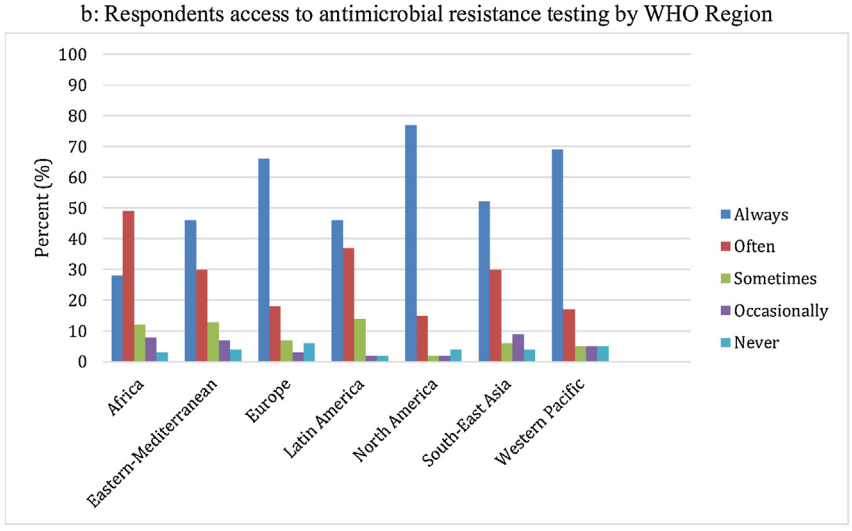


Figure 2. (a) Respondents access to equipment such as N95 respirators for airborne precautions by WHO Region. (b) Respondents access to negative pressure isolation rooms by WHO Region. (c) Respondents access to isolation gowns by WHO Region.





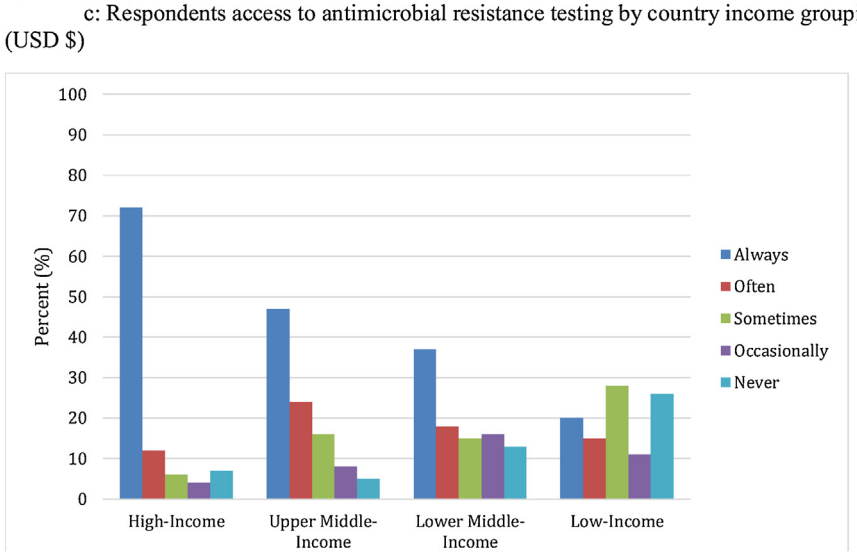


Figure 3. (a) Respondents access to personnel trained in IPC by WHO Region. (b) Respondents access to antimicrobial resistance testing by WHO Region. (c) Respondents access to antimicrobial resistance testing by country income grouping (USD $).

Table 1
Mobile Technology Use at the Workplace.

	Access to Mobile Technology			
	Mobile Use at the workplace[a]	Internet access at the workplace[b]	Operating System[c]	
			Android	iOS
Africa	153 (84%)	145 (94%)	118 (78%)	32 (22%)
Eastern-Mediterranean	84 (82%)	83 (99%)	50 (89%)	6 (11%)
Europe	148 (72%)	140 (92%)	81 (57%)	61 (43%)
Latin America	113(90%)	107 (95%)	60 (53%)	58 (47%)
North America	148(72%)	136 (92%)	50 (34%)	96 (66%)
South-East Asia	187 (86%)	177 (96%)	139 (74%)	49 (26%)
Western Pacific	62 (78%)	53 (90%)	19 (34%)	37 (66%)
Total	895 (80%)	840 (94%)	517 (60%)	339 (40%)

[a] Number (Percentage) of people who use mobile devices at the workplace.
[b] Number (Percentage) of people who access the Internet at the workplace.
[c] Note: Number (Percentage) of people who use Android or iOS mobile operating systems. A minority of respondents used alternative operating systems such as Blackberry that are not listed in this Table Some respondents indicated use of both Android and iOS device.

comparing resource settings remain limited, studies investigating local or regional infection prevention and control practices in LMICs have demonstrated similar inadequate access as our survey to respirator equipment needed for airborne precautions (Tenna et al., 2013; Kuyinu et al., 2016). The presence of IPC bundles and surveillance-associated programs at local facilities has been noted to vary disproportionately between high-income and LMICs as well (Alp et al., 2018). Access to education in IPC practices or trained IPC practitioners was also low in our survey, with less than half of all respondents across regions noting access to such techniques. Prior studies have demonstrated the importance of access to trained IPC practitioners to assist in the implementation and monitoring of infection control measures (Lipke et al., 2016; Pogorzelska et al., 2012).

Access to antimicrobial resistance testing was also noted to be widely disparate between regions as only half of all respondents noted such access. 72% of respondents from high-income countries compared to 20% of respondents from low-income countries noted antimicrobial testing capabilities. Antimicrobial resistance is on the rise worldwide, and the ability to target therapies appropriately as well as conduct surveillance is critical, particularly given limited data supporting the high rates of resistance noted in several low-and middle-income countries (Cox et al., 2017; World Health Organization, 2014). The World Health Organization has highlighted this impending crisis and next steps necessary to mitigate its impacts (World Health Organization, 2015). Despite these efforts, our survey demonstrates that large discrepancies continue to exist between regions and income groupings.

A significant strength of our methodology was the utilization of standardized questionnaire items. This allowed for uniformity in comparisons across countries and professional designation. However, our survey was limited in that it was developed for users of the *Guide to Infection Control*. There is risk for selection bias as these individuals are primed towards infection prevention and control issues at baseline, and an analysis of their responses should be considered carefully. In addition, although 194 countries were represented in the survey, the survey results may not fully represent views among all health care and public health professionals due to limited participation from certain countries. This may result in an incomplete picture of IPC practices and policies within certain countries. Despite this, the survey produced a broad representation of respondents across multiple countries and regions.

The results of this survey demonstrate that many disparities exist in the context of IPC education worldwide. The largest gaps identified in this survey were primarily related to availability of personal protective equipment, antimicrobial testing, and IPC support services. Some of these discrepancies may be due to implementation gaps as well. Although not explicitly outlined in this survey, some studies have demonstrated that many facilities lack defined infection prevention policy or procedures across country income strata, and even when present, adherence is often limited (Weinshel et al., 2015; Alp and Damani, 2015). Lack of appropriate infrastructure, financial constraints, and capacity has been highlighted in prior studies as explanations for many of the IPC discrepancies that exist between regions (Bardossy et al., 2016; Lynch et al., 2007).

Of note, the use of mobile technology was high across regions, suggesting a possible route of dissemination of IPC information in the future. Access to mobile technology in this survey was noted to be almost 80% across regions, although the use of mobile medical applications was significantly less and a large gap in technology uptake rates was observed among low- and middle-income countries. The possibility of utilizing this relatively low-cost technology for point of care infection prevention purposes may be a valuable tool in the future. This presents an opportunity for rapid, widespread dissemination of accurate information by all IPC guideline providers. Schnall et. al described current mobile phone technology and “apps” available in the setting of health care-associated infection prevention, but noted the need for further study dedicated to this topic (Schnall and Iribarren, 2015). At present, many mobile phone medical applications require payment for usage. Infection prevention education resources, guidelines, and toolkits should be open access and freely available in the health care setting. This may also improve uptake by mobile technology users and result in greater use and implementation. While widespread mobile use may indicate increasing national investments in technology infrastructure, hospital administrators should also prioritize access to basic IPC measures such as appropriate PPE and antimicrobial susceptibility testing.

The depth and breadth of our needs assessment across a society membership pool and with a specific focus on LMICs is, to our knowledge, the first of its kind. Context-specific research linking local and national networks among LMICs would be of particular interest. While there are opportunities for expanding IPC education identified in the course of this survey, additional study in the implementation of infection and control prevention practices could provide practical methods for addressing disparities in the future.

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Disclosure

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Conflict of interest

The authors declare that they have no competing interests.

Ethical approval

This work represents a needs assessment for the International Society for Infectious Diseases. Responses were voluntary and completely de-identified. As such, no ethical approval was required.

Authors' contributions

Analysis, additional literature review, and writing of the manuscript were completed by AND and JWR. Initial survey distribution was performed by JWR. BL, AH, SM, and GB assisted in the development of research concepts and manuscript editing.

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